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Guidelines for Conducting and Reporting Hydrologic Assessments of Potential Wetland Sites

PURPOSE: This technical note provides guidance on performing and reporting assessments of groundwater hydrology of potential wetland sites. Groundwater monitoring is an important and increasingly used tool for verifying the extent of wetlands on proposed project sites, and for determining whether newly restored or constructed wetlands have the hydrologic conditions appropriate for the wetland functions and plant and animal communities they are designed to support. These guidelines are intended to help project managers evaluate the adequacy of hydrologic assessments provided by permit applicants and their consultants, and should be provided to developers and environmental consultants for pre-project planning.

BACKGROUND: Evaluating the long-term hydrology of potential wetland sites is a major challenge for Corps of Engineers regulatory personnel. Consideration of hydrology is one of three required factors–hydrophytic vegetation, hydric soils, wetland hydrology–for the identification of wetlands under the 1987 *Corps of Engineers Wetlands Delineation Manual.* Wetland delineation in the vast majority of cases involves observing hydrologic *indicators* (e.g., watermarks, drift lines, saturated soils) that are used to support a wetland determination based mainly on the presence of hydric soils and a hydrophytic plant community. There are times, however, when more detailed hydrologic information is needed to evaluate potential wetland sites, including hydrologically disturbed sites where relict soil and vegetation characteristics may give a misleading indication of current hydrologic status, and certain "problem" situations where soils or vegetation may be inherently difficult to interpret. In addition, hydrologic monitoring is done increasingly to determine the potential of candidate restoration sites and to evaluate the performance of created wetlands.

Hydrologic assessments run the gamut from (1) simple observations of indicators, to (2) direct measurements of groundwater or surface water, to (3) indirect methods of estimation such as scope-and-effect equations and hydrologic models. Some of these methods were summarized by Woodward (1997). An earlier technical note described the installation of shallow groundwater monitoring wells for wetland regulatory purposes (Sprecher 1993). A related technical report described accessing and using meteorological data to evaluate wetland hydrology (Sprecher and Warne 2000). This technical note provides further guidance for conducting and reporting direct measurements of water tables on potential wetland sites.

The guidance given here is intended to be comprehensive and may not be appropriate for every project, depending on the project's purpose. However, useful hydrologic assessments do not just happen; they are the result of careful planning and execution, and can sometimes involve significant expenditures of time and money. This technical note is intended to help ensure that hydrologic assessments meet the needs of developers, regulators, and wetland restoration specialists.

APPROACH: Through a series of memos to Corps Districts and direct contacts with individual regulatory personnel, information was requested about problems associated with hydrologic evaluations of wetland sites. More than 50 individuals provided information. The authors also requested

and reviewed examples of typical hydrology reports received by Districts as part of permit applications, and any guidance that Districts had developed for distribution to applicants and their consultants. This information was used to develop a suggested standard format for reporting the results of groundwater monitoring studies for wetland regulatory purposes.

RESULTS AND CONCLUSIONS: Hydrology at individual projects is typically monitored by private consultants hired by landowners and developers. Reports submitted to regulatory offices often lack important information or contain methodological shortcomings that make it difficult and time-consuming for regulators to evaluate the quality of the data and reliability of the conclusions. Common problems include lack of information on techniques for well construction and installation, lack of justification for well placement, absence of soils information that is needed to determine acceptable depths for observation wells, inappropriate seasonal timing and frequency of measurements of surface and groundwater levels, and questionable length of record for drawing conclusions about the long-term hydrology of a site.

To address these and similar problems, a standard format is proposed for reporting the results of groundwater hydrologic assessments (see Appendix A). This same outline can be used to help guide the design and execution of a groundwater monitoring study. The format may need to be adjusted to take into account regional differences in hydrogeomorphic and climatic conditions. However, it is based on input from Districts across the country and a wide variety of landscape settings, hydrologic regimes, and site conditions.

Another persistent problem in evaluating the hydrology of potential wetland sites is the lack of standards for analyzing hydrologic data at a site in relation to local meteorological (e.g., precipitation) data for the monitoring period. Investigators of wetland hydrology need to know whether they are making their observations during a period of normal weather conditions or during abnormal conditions of drought or precipitation excess. Some guidance for determining whether rainfall conditions antecedent to a hydrologic observation were "normal" is given by Woodward (1997, Section 650.1903), based on the use of "WETS" tables available from the National Water and Climate Center (*http://www.wcc.nrcs.usda.gov/water/wetlands.html*). Sprecher and Warne (2000) describe additional sources of meteorological information and provide suggestions for analysis of local weather data in relation to hydrologic measurements at potential wetland sites.

POINTS OF CONTACT: For additional information, contact Dr. James S. Wakeley, U. S. Army Engineer Research and Development Center (ERDC), Waterways Experiment Station, Vicksburg, MS, (601-634-3702, *wakelej@wes.army.mil*) or the Program Manager of the Wetlands Regulatory Assistance Program, Dr. Russell F. Theriot (601-634-2733, *therior@wes.army.mil*) . This technical note was written by Drs. Andrew G. Warne (formerly of the Geotechnical Laboratory, ERDC) and James S. Wakeley (Environmental Laboratory, ERDC). This document should be cited as follows:

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Sprecher, S. W. (1993). "Installing monitoring wells/piezometers in wetlands," WRP Technical Note HY-IA-3.1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sprecher, S. W., and Warne, A. G. (2000). "Accessing and using meteorological data to evaluate wetland hydrology," ERDC/EL TR-WRAP-00-1, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Woodward, D. E., ed. (1997). "Hydrology tools for wetland determination." Chapter 19, *Engineering Field Handbook.* U.S. Department of Agriculture, Natural Resources Conservation Service, Fort Worth, TX.

Appendix A: Proposed Standard Format for Reporting the Results of Groundwater Monitoring Studies

SECTION 1. SITE DESCRIPTION

I. General information about the site

A. Narrative description, including directions to the site (e.g., road names, highway numbers, distances)

B. Relative geographic location within the watershed or landscape (e.g., associated with headwater versus higher order stream; in a floodplain, depression, or flat; etc.)

C. Surrounding land use

1. Significant land uses within the watershed that affect hydrologic inputs or are affected by the hydrologic outflows from the site

2. Proximity to other existing wetlands, based on National Wetlands Inventory (NWI) maps or onsite observations

D. History of the site, including major changes in land use and hydrology. Sources of information include:

1. Historical aerial photographs

2. Municipal planning records and archives

3. Newspaper accounts

4. Stream gauge records

E. Intended modifications to the site

II. Brief summary of regulatory activity at the site

A. Summary of jurisdictional determination and/or delineation

1. Date of wetland jurisdictional determination and/or delineation (include previous permit numbers or current application number, as appropriate)

2. Persons conducting the jurisdictional determination and/or delineation

III. Identification of responsible parties, including names, titles, addresses, and phone numbers

A. Applicant(s)

B. Contact person(s) if applicant is a company

C. Consultant or individuals conducting the hydrologic assessment

1. Project manager

2. Principal investigators

a. Professional credentials

b. Experience

D. Regulators and organizations reviewing the case

IV. Maps. Large, detailed maps are encouraged, but all essential maps should also be in 8.5 × 11 in. format to facilitate photocopying. Maps should include:

A. County road map with project site clearly outlined

B. Watershed map showing position of the site clearly outlined on an appropriate scale (1:250,000, 1:100,000, 1:24,000) U. S. Geological Survey (USGS) topographic map

C. USGS 1:24,000 (or larger scale) quadrangle map with overall project site, delineated jurisdictional area, and area that would be impacted by any intended development clearly identified

D. Existing land use superimposed on NWI maps; Natural Resources Conservation Service (NRCS) wetland designations should be shown for agricultural lands

E. Soils map from U. S. Department of Agriculture (USDA) county soil survey

F. Relevant aerial photographs

SECTION 2. SITE CHARACTERIZATION

I. Summary of existing information on vegetation, soil, and hydrology of the site

A. Vegetation

1. Map showing distributions of plant communities (on 1:24,000 topographic base map, unless otherwise stipulated by regulator)

2. Community structure (summarized from wetland jurisdictional delineation, if appropriate)

a. Dominant species and wetland indicator status by stratum (i.e., tree, sapling/shrub, woody vine, and herb strata). List species by scientific and common names

b. Wetland zonation (if present)

B. Soils

1. Soil series and description(s) from USDA county soil survey

2. Summary of observations made during jurisdictional delineation

C. Hydrology

1. Hydrometeorology (see Sprecher and Warne (2000) for further details on evaluating the hydrometeorology of wetland regulatory sites)
   - **a.** Range of normal precipitation for the site, determined using WETS tables for the nearest National Weather Service (NWS) station(s). See text for Internet address to download WETS tables)
   - **b.** Recent weather conditions at the site
     - **i.** WETS tables
     - **ii.** Local weather records
2. Surface Water
   - **a.** Frequency and duration of flooding or ponding (if any). Sources of information include:
     - **i.** Stream gauge data (e.g., *http://water.usgs.gov/*)
     - **ii.** Ordinary high-water mark
     - **iii.** Tide gauge data (e.g., *http://www.nodc.noaa.gov/index.html*)
     - **iv.** Documented observations, including aerial photographs
     - **v.** USDA county soil survey
     - **vi.** Wetland delineation hydrologic data/indicators
   - **b.** Source(s) of surface water, such as:
     - **i.** Overbank flooding
     - **ii.** Precipitation and ponding
     - **iii.** Tides
     - **iv.** Groundwater seeps
     - **v.** Location and types of natural surface inflows and outflows
     - **vi.** Location and types of human-made water sources (outfalls, storm drains, etc.)
3. Groundwater (background information). Sources include:
   - **a.** USDA county soil survey
   - **b.** Published soil-zone groundwater data (do not confuse with deeper, water supply groundwater data)
     - **i.** State Department of Water Resources
     - **ii.** State Department of Transportation
     - **iii.** Universities
   - **c.** Wetland delineation hydrology data/indicators
4. Summary of primary hydrologic influences within and adjacent to the site (e.g., streams, seeps, groundwater, surface water, precipitation, etc.) and human

modifications to the hydrology of the site (e.g., ditches, tile drains, roadways). Indicate on 1:24,000 or 1:100,000 scale topographic map, as appropriate

II. Reconnaissance-level hydrologic, geomorphic, and soil survey of the site (conducted to determine optimal number, location, and depth of shallow groundwater monitoring wells and other hydrologic monitoring devices; typically conducted concurrently with the onsite soils investigation)

A. Area surveyed, if not the entire project site

B. Reconnaissance team

1. Names and affiliations

2. Qualifications

C. Date(s) of field reconnaissance

D. Antecedent meteorologic conditions at time of reconnaissance

1. Complete the "Rainfall Documentation Worksheet" in Figure A1 (adapted from Woodward (1997)) based on WETS table and recent rainfall records, and attach as appendix to report

2. Narrative summary

E. Description of reconnaissance procedures

1. Hydrologic (done to confirm and refine the background information on hydraulic inflow and outflow pathways). Methods might include:

a. Remote sensing (aerial photography) analysis

b. Field methods

2. Geomorphic (include mapping of macro- and micro-landforms and identifying and evaluating major physical processes that influence long-term hydrology)

a. Remote sensing (aerial photography) analysis

b. Field methods

3. Soils (include excavation of a series of soil pits to refine previous soil surveys and identify significant shallow (B horizon) aquitards and determine their distribution)

a. Remote sensing (aerial photography) analysis

b. Field methods, including number and location of soil test pits

F. Findings of reconnaissance-level survey

1. Hydrologic survey

a. Narrative description

b. Photographs (recommended)

c. General hydrologic budget of the site (e.g., flowchart of main hydrologic inputs and outputs)

d. Map showing main pathways of surface and shallow groundwater flow into and out of site (depicted on 1:24,000 topographic map unless otherwise stipulated by regulator; show position and direction of photographs taken to characterize hydrology)

2. Geomorphic survey

a. Macro- and micro-landforms on the site

i. Narrative description

ii. Photographs (recommended)

iii. Landform distribution depicted on 1:24,000 topographic map, unless otherwise stipulated by regulator (also show position and direction of photographs taken to characterize landscape)

iv. Proposed locations of hydrologic monitoring devices

b. Principal processes influencing long-term hydrology of the site (e.g., significant ongoing sedimentation, slumping, or scouring)

3. Soil survey

a. Narrative description of the number and location of soil pits excavated for the investigation

b. Description of soils at the site including horizonation, color, texture, redoximorphic features, and other hydric soil indicators

i. Narrative

ii. Table of horizon depths and characteristics for each soil pit

c. Identification and description of potential aquitards that may influence vertical shallow groundwater flow

d. General cross section(s) of soils at site; information on cross sections should include general soil stratigraphy and proposed depths of monitoring wells and hydrologic monitoring devices

e. Map showing locations of soil test pits, distribution of soils as determined by the reconnaissance survey, cross-section lines, and proposed locations of monitoring devices; depict on 1:24,000 topographic map unless otherwise stipulated by regulator

SECTION 3. MONITORING PROGRAM

I. Types of monitoring devices used

- **A.** Description of instrument(s)
- **B.** Reasons for instrument selection

II. Determination of monitoring locations and depths (based on site reconnaissance)

- **A.** Narrative descriptions
  - **1.** Number of locations
  - **2.** Choice of locations and depths
    - **a.** Overall strategy
    - **b.** Each location
- **B.** Map showing monitoring locations (1:24,000 topographic map, unless otherwise requested by regulator)

III. Installation of shallow groundwater monitoring devices

- **A.** Shallow groundwater monitoring wells (see recommended procedures in Sprecher (1993))
  - **1.** Narrative description
    - **a.** Materials used
    - **b.** Well design (e.g., diameter, extent of slotting, surface seal, well cap, etc.)
    - **c.** Installation procedure
  - **2.** Construction diagram
- **B.** Other monitoring devices, if used (see Faulkner et al. (1989))
  - **1.** Narrative description
    - **a.** Materials and design
    - **b.** Installation process
  - **2.** Construction diagram

IV. Monitoring procedures

- **A.** Shallow groundwater (soil-zone) monitoring wells
  - **1.** Non-automated wells
    - **a.** Method used to measure water levels (depth below ground surface)
    - **b.** Name(s) and organization(s) of personnel measuring water levels
    - **c.** Portion of the year that water levels were read

d. Frequency of water level measurements

e. Duration of monitoring program, including justification

2. Automated wells

a. Procedures used to calibrate water level readings (depth below ground surface)

b. Portion of the year that water levels were read

c. Frequency of water level measurements

d. Schedule of data download from well data recorder

e. Method for transforming well data into readable format

f. Schedule for recalibrating water level readings

g. Duration of monitoring program, including justification

B. Other monitoring devices, if used

1. Method(s) used to extract data from device and convert to format for analysis

2. Portion of the year that soil parameters were read

3. Frequency of measurements

4. Duration of monitoring program

V. Monitoring program results

A. Summary of hydrometeorologic conditions during monitoring program (see Sprecher and Warne (2000))

1. Precipitation records

a. WETS tables from closest NWS weather station(s) that reflect conditions at the site

b. Tables showing precipitation records for the period of study

2. Graph showing precipitation conditions during the monitoring period and their relationship to long-term precipitation norms

3. Narrative summary

B. Shallow groundwater monitoring wells

1. Table of water level readings

2. Graph showing changes in shallow groundwater level over time and its relationship to precipitation conditions

3. Narrative summary

C. Other shallow groundwater monitoring devices, if used

1. Table of readings

2. Graph showing changes in measured soil parameters over time and their relationship to precipitation conditions
3. Narrative summary

VI. Discussion and conclusions of the groundwater monitoring study

Rainfall Documentation
for Evaluating Hydrologic Observations

Today's Date: _____

Site Name/Number: _____ Landowner: _____

County: _____ State: _____

Soil Series: _____ WETS Weather Station: _____

Date of Aerial Photo or
Hydrologic Observation: _____ Growing Season
Start/End Dates: _____

		Long-term Rainfall Records (in.) (from WETS Table)							
	Month	3 yrs in 10 less than	Average	3 yrs in 10 more than	Observed Rainfall	Condition (dry, wet, normal)	Condition Value**	Month Weighting Factor	Product of Previous Two Columns
1st month prior:*								3	
2nd month prior:								2	
3rd month prior:								1	
								Sum =	

*In relation to photo or observation date

**Condition Value:
Dry = 1
Normal = 2
Wet = 3

Note: If sum is
6-9 then prior period has been drier than normal
10-14 then prior period has been normal
15-18 then prior period has been wetter than normal

Conclusions:

Figure A1. Rainfall Documentation Worksheet (adapted from Woodward et al. (1997))